TENTH REPORT
OF
THE MICHIGAN ACADEMY OF SCIENCE

CONTAINING AN ACCOUNT OF THE ANNUAL MEETING

HELD AT

ANN ARBOR, APRIL 2, 3, 4, 1908.

PREPARED UNDER THE DIRECTION OF THE COUNCIL

BY
WILLIAM S. SAYER,
SECRETARY

BY AUTHORITY

1908

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LETTER OF TRANSMITTAL.

TO. HON. FRED M. WARNER, *Governor of the State of Michigan:*

SIR—I have the honor to submit herewith the Tenth Annual Report of the Michigan Academy of Science for publication, in accordance with Sec. 14 of Act No. 44 of the Public Acts of the Legislature of 1899.

Respectfully,
WILLIAM S. SAYER,
Acting Secretary of the Michigan Academy of Science.
East Lansing, Mich., May 28, 1908.

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The Council is composed of the above named officers and all Resident Past-Presidents.

*Deceased.

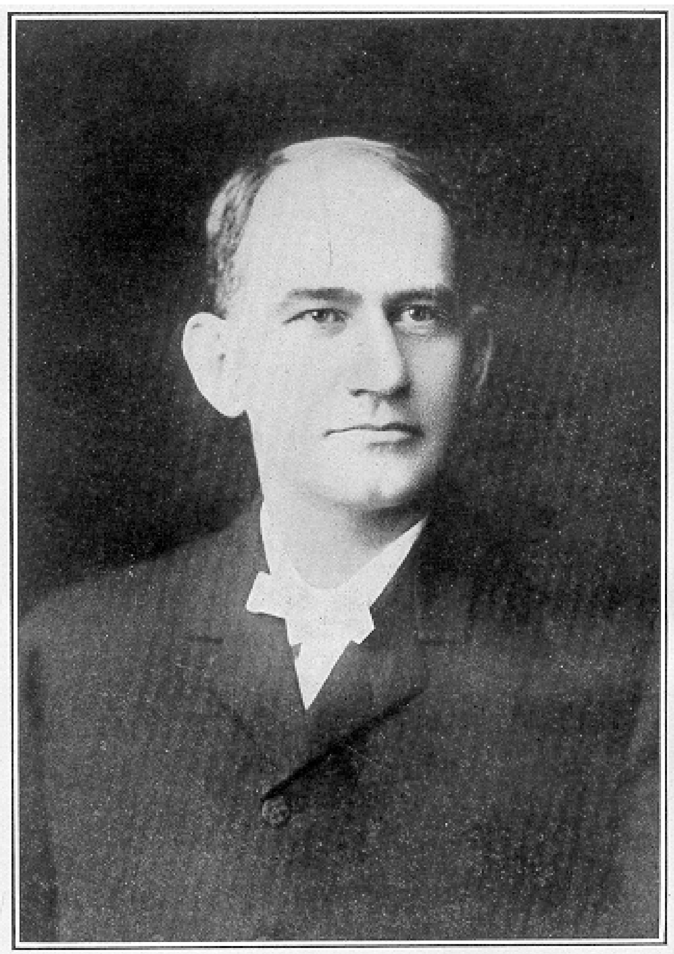
ERNEST EVERETT BOGUE.

ERNEST EVERETT BOGUE was born January 13, 1864, in Orwell, Ohio. He was of French Huguenot stock on his father's side. There were nine children in the family, six of whom with the mother are still living. Mr. Bogue's early ambition was to gain a higher education, and to this end he constantly worked, earning most of the money with which to defray his expenses at school and college. He taught one term of district school; spent three years at New Lyme Institute, where he graduated in 1888, and in the fall of 1889 entered Ohio State University, from which he graduated in 1894 with the degree of Bachelor of Science in Horticulture and Forestry, and in June, 1896, he received from the same University the degree of Master of Science in Entomology and Botany.

He loved trees, plants and music, and the home surroundings and associations and education in the University all tended in the same direction.

He married on March 25, 1896, Miss Myra V. Wilcox of Columbus, Ohio, and went immediately to Oklahoma as head of the department of Botany and Entomology of the

State Agricultural College, resigning in the spring of 1900, after teaching four years, to take post graduate work at Harvard University, from which institution he received the degree of Master of Arts in June, 1902. In September of that year he accepted the new chair of Forestry in Michigan Agricultural College, where his skill, originality, ingenuity and genial ways soon attracted a large class of students. He took great interest in the subject of Forestry throughout the State, visiting many of the leading farmers to encourage and help them in plans for the correct management of their wood lots, and in starting original plantations. A map of the State hung in his office well dotted with red spots showing the localities of these early efforts by farmers of Michigan. He was likewise much interested in plans to improve the stump lands in the north part of the State, and in experimenting on the wild lands of the college located in the same region.



PROFESSOR ERNEST EVERETT BOGUE.

He started a forest nursery, a part of the plan of which was to furnish young trees at cost for the farmers to plant. For the beautiful home erected he selected a congenial spot near the papaw bushes, sloping to the bank of the Red Cedar, where the dam below made a delightful place for rowing for over a mile in extent. Pitcher plants, orchids and numerous wild plants of his selection occupied suitable spots between the house and the river. With excellent judgment, he selected a nice variety of trees and planted about his new home, among them a fine grove of Norway Spruces, with the view of furnishing Christmas trees to the neighborhood when they should attain suitable size. The chief charm of the location, as he rightly viewed it, was just across the river on the farm, a virgin forest of maples, beeches, basswoods, elms and others delighting in such surroundings.

He was a man of deep religious convictions; but his creed was formulated in acts of Christian living rather than in words of belief. He was long the superintendent of the Sunday school near the college.

After a protracted illness, he died August 19, 1907, as we might say in the midst of a promising career of usefulness, as a man, a citizen, and a teacher.

W. J. BEAL.

MAN IN WEST NORWAY.

If we can answer the question where in the world something is, we are talking geography. If we can tell why these people are there, why more numerous than elsewhere, why more happy or more wretched, we may be talking geography or we may be talking history. The conscious and purposeful activities of men, Prof. Burr tells us, belong to history, leaving their yieldings to environment and their driftings with the current for geography. I am not attempting to define my science but to illustrate its bearings by a concrete example.

On the old continent of Europe man has densely populated those regions that he has found favorable to his prosperity. He has not always displayed especial intelligence in selecting these spots; he has groped about somewhat, now settling on lands that looked promising to him, now wresting their homes from prosperous-seeming predecessors. He has made mistakes which nature has explained to him by gently withholding her bounty. But after many centuries of trial and contention he has doubtless come to inhabit the most suitable parts of the continent in greatest numbers.

Now in Norway precisely we find men spread out thinner than anywhere else in Europe. For Norway, larger than all Great Britain and Ireland, has barely a twentieth as many inhabitants. Our young state of Michigan with only half the area already has more people. The Norwegians are really so few that the part they have played in history, the contribution they have made to human development and culture is somewhat astonishing in a bare two million of people. The sea was always in the story for they came to their land by sea, by sea they moved about it of old and still today, by sea they wandered along every European shore, wresting territory they named Norman from the French king and centuries of spoils from the British islanders, even anticipating in their restless cruising the great exploit of Columbus. Today, though fewer than any European people they are fourth in world-rank as owners of merchant ships. In their own continent only England and Germany lead them.

Whatever springs of racial, social or historic character may have contributed to so much of achievement, I see here the influence of an inhospitable land to which its dwellers only cling with difficulty.

Modern geography sees nothing in the Renaissance so fruitful of human culture and progress as the recognition of the ocean as man's highway. That was the gift of Columbus to his fellow men. That the world was round was known in Plato's day. That a voyage due west from the straits of Gibraltar would bring a ship in time to India had been written down for nearly twenty centuries. But that man could break away from the land and sail straight away to the ends of the earth was a view that began to dawn on men with Columbus' voyage. Beginnings of culture had already come to the races that had learned to move about the Mediterranean, groping always from point to point. Not that man voyaged for culture in those days. It was dominion, power and wealth that was sought, the neighbor's goods taken with the strong hand too often. Similar the quest of Norsemen in France and Britain, of Portuguese and Spanish in America. Once the overpowering fear of the ocean vastness was put aside it was a summer excursion, this voyage from Spain to the West Indies. Down the steady trades by the African coast to the Cape Verds and thence on the same steady winds they sped across the Atlantic, on pleasant sunlit seas. Anything that would float was a ship, anyone that would go was a crew, anything was a sail that would hang on the yards and catch the breeze to waft them oversea to the land of gold. To return against the wind was less easy always, but then they would be rich and what matter the discomforts of the voyage? No sailors these; they had no need to be. How different in the North! On storm-swept seas with shifting winds in fog and mist. Sea-faring is a trade here that only the bold-hearted venture on. The weak and the incompetent succumb to the dangers of the sea or flee from them in terror. No school of seamanship could be sterner nor finer than the North Atlantic. This was the school in which the Norsemen learned their trade, here the Dutch and the English sailed the seas. For them the voyage to America was a constant struggle against head winds varied by furious storms. It could not be long before they met the Spaniard on his southern waters and wrested from him the treasures he brought from Mexico or Peru. Presently the Invincible Armada appeared in the English Channel and the English, sailing out in their snug, staunch little ships, met them and drove them down the gale fairly around the British islands to perish—with Spain's pretension to rule the seas. It is significant, it seems to me, that the handful of Norsemen who learned the sea-path in the middle ages should spread their name and deeds so widely and even anticipate Columbus in reaching the new world. Among continentals of this period there was much wandering of armed men as there had been even in Caesar's day. But these were land wanderings, the horse was the costly means of movement and the knights or horsemen are even today in those lands the upper class of society. Nobility was abolished in Norway in 1821, but the essential noble class in the land is its seafarers. Sunday throngs at the boat landings in West Norway show a true peasant class, dull, heavy faced and slow of movement. But the boat officers or even the crew are another type of man, men in whose bearing one sees their possession of the freedom of the earth. At home they had hardly a foothold on a rugged coast. They were not numerous enough to colonize: they founded no empire as did the English whose land is generous enough to support three hundred and sixty people on every square mile. In Norway only three per cent of the land is fit for cultivation, the rest is bare mountain, rock or forest. Eighteen inhabitants to the square mile are crowded there after a thousand years. In our new land we are already near to thirty, in Michigan, forty-five.

For the geologist and physiographer Norway exemplifies the full development of a type of landscape hinted at by nature in Northern Michigan. It is a land short of dirt. The rocky skeleton of the earth is there too much in evidence. If our earth is a ball of rock with a mere dustlike layer of soil on it, here we must bore down a hundred or two hundred feet to get at the rock. Not so in Norway, nor in New England nor in Upper Michigan.

In seven hundred miles of Norway I saw no landscape without its rock expanses often more than ninety per cent of all the view. There is also much kinship in the northern rocks. Steam by the north of Scotland south of the Orkney islands and the land border is a cliff falling sheer to the water or overhanging. Above is a gently undulating land well clothed in green growths. The rocks are sandstones that lie flat in layers. The cliff is the broken edge of the layers. Just such, only smaller, are the cliffs of Put-in-Bay in Lake Erie, at Point aux Barques on the Thumb, or at Petoskey in Little Traverse Bay, and the rocks are just such in lower Michigan, only well seen at such points on the edges of the peninsula, for here too they lie flat in great leaves or sheets. But across the North Sea in Europe or across Lake Huron and North Bay in our Lake region we come to another type of scene, so like in both cases that nothing in external nature tells us whether we are in the old world or the new. Hummocky tumbled granites in knobs and round waves of rock descend steadily if unevenly from the land beneath the sea. Seaward the knobs are all but submerged, a fringe of countless islands all of whose contours are round and smooth but of curves that are of short radius and constantly interrupt each other, intensely rugged, but the ruggedness is one from which all minor roughness and sharpness has been removed by some polishing agency. Naked toward the sea the shoreward face of brown islet and peninsulars scantily clad with plants. These resemblances across the Atlantic rest on a broader similarity in the structure of the continent.

Glance for a moment on our map at the great chain of hollows between the mouths of the Mackenzie and the St. Lawrence, the great Canadian Lakes, as the old world calls them, including Great Bear, Great Slave, Athabasca, Reindeer and Winnipeg as well as the five that we regard as ours. They lie along a four thousand mile curve encircling Hudson Bay. Broadly speaking the rocks north of this line are all ancient, crumpled, fireworn, Archaean rocks. South of the lakes the same lie deep beneath the flat layers of Paleozoics. It is on these flat lying rocks that most of the American people live. These are the great flat sheets of rock whose edges were said to crop out at Petoskey, at the tip of the Thumb and in the islands of Lake Erie. Among them are the Carboniferous rocks that carry our coal beds.

In Europe a similar line of depressions may be followed through North Sea, Baltic, Gulf of Finland, Lakes Ladoga and Onega and the White Sea, under water most of it here, it stands so low. Here again for a rough description we may say that the rocks to the north are all the ancient gnarled Archaean; to the south appear the flat lying layers on which live the mass of Europe's people, English, French, German and Russian. It was a sample of this that we saw in the Orkneys and northern Scotland.

These contrasts in the land nature are fairly well followed by the tree sorts on the two regions, to the north, needle-bearing conifers, to the south, broad-leaved, deciduous trees, though there are numerous excursions of either sort across the boundary, as for instance the pines on the Paleozoics of the southern peninsula of Michigan.

The Baltic Shield of Archaean as has been said displays a type of land form strongly hinted at in the Archaean V south of Hudson Bay. The northern rocks in both cases are fused, molten, crystalline and hard, those of the south dull, earthy, layered and soft. Millions of years of weather had rotted and softened both kinds till their surfaces lay deeply buried in the resultant soils when another and singular thing befell. Its effects were much like the dragging of innumerable brush harrows southward across the Archaean areas and over the border of the southern cover layers.

Details belong to geology. It is the story of the Ice Age. The process swept off the decayed and softened surface portions of the Archaean rock, baring firm, sound, unweathered rock below, which is smoothed and polished at the same time that it left it hummocky and nubbly as its gnarled and crumpled structure demanded. As the sweeping process did not extend far into the southern areas their rocks were rarely stripped, but rather received the sweepings from the north upon their own soils. Thus it happens that our fields in southern Michigan have abundant mineral matter from the country north of our Lakes, and Scandinavian rock waste abounds in England, Germany and West Russia. It was in that sweeping process that our field stones, so much firmer and more suitable for building purposes than the rocks found by deep borings under us here—were imported, mostly from Canadian territory.

We know our north country to be a wilderness of rock and forest, therefore a vacation ground for the denser population to the south. It is likely, always to remain so, not as any result of the newness of American settlement, but it rests on physiographic grounds as in our European example after long centuries of effort. The physiographic contrast in Europe is stronger than here as we shall now see and where our population falls off from thirty to the mile south of our Lakes to three or four on the north, Germany with two hundred is to be contrasted to Norway with eighteen.

It is precisely in Western Norway that the land is rockiest, there where the sea penetrates deeply into the land in the three great Fiords, Hardanger, Sogne and Northfiord, extending even sixty miles from the ocean. Offshore is an island swarm identical in origin with the Ten Thousand Islands of Georgian Bay and innumerable channels between. The waters are still, so still it is hard to believe them a portion of the Atlantic Ocean, but any wider space between the islands at once sets our little steamer rolling violently. Nubbled, rounded and hummocky are the rocks all along; on the face toward the land picked out with heather in every crevice but on the ocean side brown and bare. Where shall man live in such a region? We turn a corner to the eastward and enter the harbor of Bergen. It is one of the best footholds west Norway affords. To appreciate it l3etter let us turn our backs on the city as if starting on up the coast to northward and there we see man again losing his foothold on the crumpled rock. The houses seem to cling as long as the slope is gentle enough to let them stick, but it is dirt that is scarcer even than houseroom here.

Bergen lies at the mouth of a mile-wide valley that continues for several miles to the south and west until it comes again to the sea. It has no river but lies flat-bottomed and floored by park-like fields and estates between cliffs a thousand to fifteen hundred feet in height. It needs but a gentle depression to sink the valley floor beneath the sea and produce another sound-like passage among islands. Such it was not many thousand years ago. This soil gathered on the sea bottom, the washings of the land, and almost every foothold man has found in the region has originated in a similar way. The seventy thousand people find it footing scant enough. We may see the city streets climbing high on the valley wall, macadamized, supported by granite walls where the zigzags double on each other and provided with iron hand rails for the foot passenger. The steepness allows the houses to have street entrances at each story. This portion of the city a member of the Norse parliament told me, was not used for residence by the well-to-do classes, not because it was not good for house sites but the land was so cheap there that the poor crowded them out. He did not entertain the idea that there was a geographic reason for this cheapness. But we may go far above the highest of the houses, following the admirable road to a height of a thousand feet on a shoulder of hillside where we may rest at a little restaurant and look out across the whole region, solitary upland, populous valley, fiord, island and Atlantic. Behind the restaurant a narrower path leads on and we soon have before us a sample of the stuff the land is made of. We are at an elevation of twelve hundred feet on a mile wide bench. Across the foreground runs the path of crushed stone resting in the heather on a foundation of peat that makes it yield like velvet to every footstep. Further back rises another seven-hundred-foot cliff of purplish gneiss, almost entirely bare. There is little frostwork here. It is too mild under the breath of the Atlantic,

One sees little rock that has fallen from above. A little further the truth of this observation is emphasized by the clearness with which a single exception stands out on the valley wall; above a light gray scar, below the light gray pile into which the falling rock resolved itself. Every flat surface has its peaty soil and growth of heather. The rocks are everywhere wet and glistening. Down at sea level the rainfall is double that of Michigan, up here probably more still. Plants grow on any pretense of soil. Looking from the summit landward I estimate the bare rock as forty per cent of the landscape here. In every hollow a lake gathers with water plants and mosses busy filling all about the border. So if we turn and look below to the bench above the restaurant. The heather cover is closer here. And the bog plants have come nearer to filling their pool. But green as the whole ground is, it has no soil that man can use; only heather and moss can grow upon it. Man is confined to the narrow valley, the great upland surface of the land has no inhabitants. Northward we shall see more desolation, slopes of birch at the waterside, above that heather and over that the desert of bare purple rock and snow.

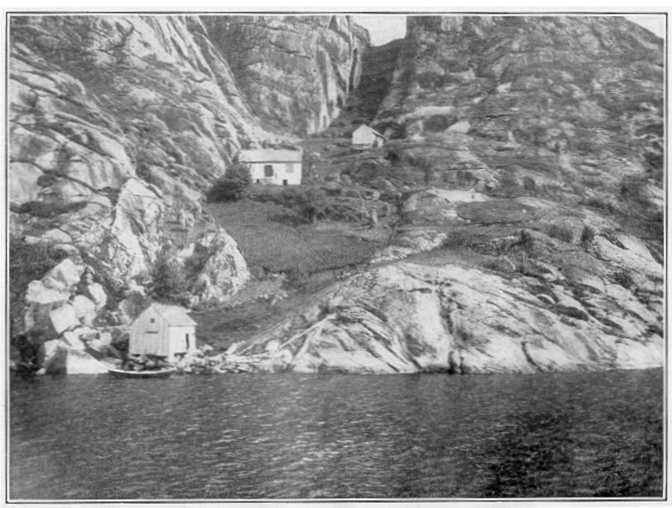
We turn presently into the Northfiord, passing an occasional group of little houses at the water's edge. For hour after hour one must estimate bare rock the larger part of the landscape. Of what plants are there, only a narrow stripe of yellow grass along the fiord edge at the old sea level is of use to man. This fiord is some sixty miles in length to hardly three in width. It is enclosed in strong slopes descending from snow-spotted uplands two or three thousand feet above. In the sunlight it is grand but gloomy more often when roofed over tunnel-like by clouds that hang below the summit of the walls on either hand. At the fiord head is a mile-square patch of land that has inhabitants. It was anciently a delta of mountain streams built into the head of the arm of the sea when the land stood a hundred and fifty feet lower. Looking back over the fiord from this terrace, the scene is one of greater promise for men. Here on the terrace and about the lake above 368 people dwelled in 1904. The valley has been settled a thousand years. The land under such circumstances is very precious. It has no ascertainable price. It is not bought or sold. Each point has its own name and the people all have that name too. Thus the main settlement Loen has thirteen peasant proprietors and "always has had." Each of these families is named Loen, the individuals being distinguished by their Christian names commonly with the addition of their father's name, as Marcus Andersen Loen, Rasmus Johansen Loen, Anders Marcussen Loen and so on. Frequently individuals are found with the name of a neighbor settlement, but the rarity of this denotes fixity of residence through the generations.

Closer to the shore are more signs of men in the landings where are stored the things that come and go in boats, And there is no other approach. There is a road up to the lake, there is a steamer on the lake, and the valley beyond finally heads up at the glacier and cliffs leading to an upland a mile above the sea. All who go up the road come down. The skipper of the steamer declines your fare on the up trip. You will come back later, you may pay then. If you raise your eyes from the landing they sweep up a long slope of birches a little striped by rock and snow falls from a niche in the cliff, then up a steep brown face of rock to a platform at three thousand four hundred feet above the fiord steamer at the landing. If we take the camera and climb, in five hours we may stand above and see the whole valley spread out in bird's eye view. Under us the fiord, the terrace on which stand the scattered houses of Loen and the road beside the river to the lake, three miles away.

Both lake and fiord are of fresh water here, tho the tide rises and falls four or five feet twice each day. No salt can be tasted in the fiord for many miles toward the sea. It is in such spots as this on each of the branches into which the fiord divides at its head that all the inhabitants of this part of the kingdom must live. The area here is small, the most distant wall being barely twelve miles away, but very hazy and blue with the water vapor in the air. If we walk along the road we find the scene park-like with the mountain walls always towering far above the trees, while the far-from-silent river alongside puts a good deal of action into the scene, especially on the hot days, when the ice above melts freely. During much of this walk we have a summit in the background six thousand six hundred feet above us, a mount Washington with its feet at sea level. Presently we pass the last fall and come to the level of Loen Lake. A glance back shows us the cliff we just ascended with its crest now above the clouds. Just before us is a tiny farm with all its lands. Over across the foot of the lake is a yet tinier one. This is known as a one man place. When the son was grown he had to emigrate. All the farm lands are in sight. They are not cultivated by machinery. Part of the water that leaps so abundantly from above is utilized on one farm for a fulling mill, part of it for the farm grindstone, or tumbling wastefully over the grass when the sluice is closed.

There is a good deal of wood in the valley on all the lower slopes. From this the tips of the birches are cut when tender and dried to eke out the scanty store of winter hay. Further back the Scotch spruce is still abundant. Houses here are of course of wood and though essentially log cabins that have been *tamed* by a thousand years of experiment into a curious affair of dressed and dovetailed timbers. It is made of planks four inches thick, and tongued each to the one above. There is no frame. The planks are dovetailed together at the corners, and partitions and floors are dovetailed through the solid sides. When the windows are sawed out, a slab is nailed across the space between them to hold the planks there together until they are supported by nailing to the window frame. Outside these planks goes an outer sheathing of inch-thick clap-boards. When roofed with slate such a house gives an effect much like that of our frame buildings. The mere log cabin only occurs on the mountain pastures where the cows pasture through the summer and the girls go up daily from the fiordside to care for the milk. These and the poorer houses are roofed with sod, often underlaid by birch bark to keep the rafters from rotting. The better buildings are everywhere roofed with red tile.

The brick and stucco houses of the cities are often of excellent design. Above the Loen Lake where ice and snow abound the slopes are full of the work of ice, wrecking and burrowing. This happens not merely at the summit of the cliff where the ice must fall over the edge, but at every point on the slope where it rests there a great hole is dug. Little isolated glaciers that lie high up on the mountain side are always margined on the upper side by a cliff one or two hundred feet high as if showing how much the ice has recently sunk itself into the rock. Just below, if we are above the level where ice sometimes melts, lies the rough heap of moraine, big as the glacier itself and witness to its excavating power not only by the mass of rocky debris but also by the fresh unweathered gray color, while the cliffs all about are brown and purple.



A COMPLETE TYPE OF LIFE IN WEST NORWAY.

Up beyond Loen Lake the valley is not unlike. The walls are steeper here, the scene is grander, for the upland surface is a mile above us and on it for three hundred and sixty square miles here rests the greatest glacier of Europe. There is little footing for continued human occupation, though. Near the lake head stood in 1904 two little settlements of Bodal and Naesdal, with sixty inhabitants between them. In the following winter almost every individual perished in a great wave from the lake, caused by the fall of an enormous mass of rock from the cliff above.

Above the lake head the ground is too stony to cultivate. We may go up through the alders for two miles and emerge on a glacier bed which the ice abandoned only a few years ago. The trees end at the wall like ridge of stones the ice had earlier pushed before it. Upon the valley floor we now perceive the river winding from side to side strewing it all across with stony waste. Beyond, the glacier closes the valley, dull and dirty looking under the clouds, but glittering white when the sun bursts forth. We see then that there is little dirt upon it. Mostly it is white, clean ice resting on clean coarse gravel, with our river issuing from a blue cavern in the end.

If now in our search for places where men-may dwell we climb five thousand feet above and look across the valley of the Loen Lake to the upland, the midsummer landscape of snow and ice shows little promise. From the highest point in the region the prospect is even worse, a broad expanse of white picked out with rock. Such is west Norway seen from on top. Of such a land only the edges are usable. We saw some bits of habitation on the old sea bench beneath. At Froen it appears as a distinct bench on the landward side of one of the coast islands; dwellings and bench appear plainly. Outside on the ocean border where the cliffs are stripped bare by winter storms, a line of caves with a faint bench between marks the same ancient submergence of the land. It would hardly be possible to maintain life in a spot so exposed but just within the entrance to the nearest fiord we find human dwellings in a place only better in its shelter from the ocean winds. They are not summer camps, but permanent homes. Further up the fiord is a tiny farm that seems to me the completest type of human life in west Norway, though there may not be many like it.

A dike of softer rock has weathered back and formed a gully with soil on its floor. To right and left is only barren cliff of rock. At the water's edge the boathouse, the boat moored beside it; in the middle of the narrow stripe of grass the dwelling, and high above the shed that serves for barn; all three combine to show the Norseman making the most of every scanty patch of earth as he clings to the edge of a rocky land, ready always to fare out upon the waters.

MARK JEFFERSON,
Ypsilanti, Mich., April 3, 1908.

A BOTANICAL TRIP TO THUNDER BAY ISLAND.

C. K. Dodge.

Thunder Bay Island is in Lake Huron about twelve miles east of the city of Alpena, Alpena Co., Mich., and four miles east of North Point, the nearest mainland. It contains about 145 acres. On the east side is the light house, on the west side, the United States Life Saving Station, at present managed by Captain John D. Persons, a genial and intelligent man, who welcomes geologists, botanists, and all scientists. The island is a solid limestone rock, just above the water, built up ages ago. The soil covering is generally very light, and in many places a considerable distance away from the shore the rock is exposed. In the center, the drift may be several feet thick. The island is occupied only by light house and life saving employes and their chiefs. Very little attempt is made at cultivation of the soil, even for gardening. Near by at the north west is another rock rising above the water, and covered with drift, called Sugar Island, and another one called Gull Island not occupied at present, both showing some signs of former habitation, probably by fishermen and being well covered by vegetation. North Point is a projection of drift-covered limerock from the mainland to the south, partially dividing off from the Lake the body of water called Thunder Bay.

Thunder Bay Island is a veritable emerald gem out in the sea and should have had a name corresponding to its beauty. It was visited June 22, 23 and 24, 1907, mainly to rediscover and secure specimens of a dark-fruited thorn, at present known as Crataegus borealis Ashe, reported as found there by Prof. C. A. Wheeler over ten years ago. After a thorough search not a thorn of any species could be found on that island. But on Sugar Island fine specimens of Crataegus punctata Jacq. were noticed in abundance, not yet in bloom, nor did they bloom till the first week in July. Failing to find the main object of the search, attention was turned to other plants. The principal tree of Thunder Bay Island is Abies balsamea (L.) Mill, of small size growing thick especially on the western half. In a few places Thuja occidentalis L., Larix laricina (DuRoi) Koch., and a very few of Fraxinus pennsylvanica Marsh, were noticed. Among these also were many small shrubs of Acer spicatum Lam., being of larger size and very abundant on Sugar Island. One fine speciman of Sorbus americana Marsh. was noticed. In many places Alnus incana (L.) Willd. was abundant. Not an oak, beech, hickory or elm was seen. Salix glaucophylla Bebb occurs at the north end. Juniperus sabina L., bearing fruit in abundance, covered the ground in many places, having the appearance at first of a Lycopodium and at North Point on sandy ridges it was abundant. At the south end Malus malus (L.) Britton was frequent, low and scraggy, and in full bloom June 24. It is reported that many years ago a cargo of apples was wrecked there. Lonicera hirsuta Eaton and Ribes lacustris (Pers.) Poir. were frequent. A large bunch of Ribes prostratum L'Her was noticed on Sugar Island and at North Point Vaccinium canadense Kalm. At the upper end and on the west side of Thunder, Bay Island were found Carex setifolia (Dew.), Britton, C. sartwellii Dew., C. crawei Dew., C. lanuginosa Michx:, C. scirpoidea Michx., C. aurea Nutt., C. aquatilis Nutt., C. capillaris L., and C. marcida Boott., the last perhaps new to the state. Triglochin maritima L. was frequent. In the most shady parts were found a few specimens of Lycopodium annotinum L., L. obscurum L., Calypso bulbosa (L.) Oakes, Corallorhiza corallorhiza (L.) Karst., and Trillium cernuum L. More in the open fine specimens of Corallorhiza striata Lindl. were frequent. Iris lacustris Nutt. in damp places on the island and at North Point, just coming into bloom, covered the ground. Fragaria canadensis Michx. and Primula farinosa L. were common, the latter just going out of bloom. Houstonia ciliolata Torr. was plentiful in open grassy places. At the north end along the edges of slightly projecting lime rock, and about little pools of water, where the rising waves often cover the rocky shore, was noticed the slimy-leaved Pinguicula vulgaris L., its first appearance reminding one of a violet. On the west side in rich shaded ground were noticed in abundance small specimens of Washingtonia divaricata Britton, new I think to the state. At North Point growing on sandy ridges, were found thrifty and abundant specimens in one place of Adlumia fungosa (Ait.) Greene, Capnoides aurea (Willd.) Kuntze, and Leucophyllis graridiflora (Hook.) Rydb. Anemone hudsoniana Richards, Coreopsis lanceolata L., Rubus odoratus L., Arabis holboellii Hornem. and Quercus rubra were common on sand ridges.

There seems yet to be ample room for botanical research in that part of Michigan.

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PLEISTOCENE BEACHES OF SAGINAW COUNTY.

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Introduction.

For an account of the Glacial Geology of the "Southern Peninsula of Michigan," the reader is referred to an article by F. Leverett in the Sixth Report of the Michigan Academy of Science, 1904, page 100. During the present year the same author has prepared the report on the Glacial Geology of the Ann Arbor Folio, No. 155 of the U. S. Geological Survey publications, in which will be found a general summary of the glacial geology of the Lower Peninsula. Prof. James W. Goldthwait of Northwestern University, Evanston, Ill. has prepared Bulletin 17 for the Wisconsin Geological Survey in which will be found an excellent historical and geological review of the Pleistocene Lake History down to 1906. For a general account of glacial geology those interested in this subject would do well to read Chapter XIX on the Pleistocene in Volume III of Chamberlin & Salisbury's Geology, printed in 1906.

Centers of Ice Radiation.

As far as the geology of Michigan is concerned we only have two centers of ice accumulation and dispersal to deal with, namely the Keewatin ice sheet in central Canada and west of Hudson Bay, and the Labradorean which takes its name from the peninsula of that name in eastern Canada.

During the advances and retreats of these great continental glaciers there have been separated six epochs of glaciation beginning at the bottom as follows: Jerseyan, Kansan, Illinoian, Iowan, early and late Wisconsin. In the intervals of deglaciation are found early indications of soil deposits between the different sheets of drift all of which have been given a nomenclature and it furthermore seems probable that some of these intervals of glaciation exceeded in time, the period since the last glacial epoch closed.

Radiating from these ice masses there are along the southern border of the last glacial epoch a. more or less pronounced lobation of the ice. Thus in the area of Lake Superior the Keweenaw and Superior lobes were developed; along the axis of Lake Michigan the Green Bay and Michigan lobes; in the Huron-Erie basin the Saginaw lobe and the Huron-Erie lobe.

Lake History.

As the ice border withdrew to the north the glacial waters were ponded between the ice on the north and land divide to the southward. The history of these changes has been described by Chamberlin and Leverett in the reports referred to above. In brief, we first have Lake Maumee impended by the Erie lobe and escaping through the lowest available col at Fort Wayne, into the Wabash, and thence to the Gulf. In the second stage of Lake Maumee consequental to the further retreat of the ice we have the waters draining off through the Imlay outlet in the eastern part of Lapeer county, around the edge of the Saginaw ice-lobe to the valley of the Grand River. Somewhat later Lake Saginaw came into existence, coincident with the retreat of the Saginaw glacier and this crescentic lake drained off through the Pewamo passage into the Grand River outlet, and thence through Lake Chicago and the Illinois route into the Mississippi. During a portion of the existence of this Lake Saginaw we have Lake Maumee still discharging through the Imlay outlet into Lake Saginaw but later on in the retreat of the ice, a lower outlet across the "thumb" of eastern Michigan was opened and the Imlay outlet was abandoned.

Later on we have Lake Arkona with the Belmore beach and Lake Whittlesey the resultant of the readvance of the ice, discharging through the Ubly outlet, and for a time submerging the Arkona beaches which were partially obliterated. At a still later stage Lake Warren came into existence, contemporaneous with the withdrawal of the ice from the "thumb" and allowing the waters of Lakes Saginaw and Whittlesey to unite. At first the drainage was westward through the Grand River valley until the ice retreat to the eastward furnished a drainage channel through the Mohawk valley.

At a still later date Lakes Algonquin and Nipissing came into existence consequental to the further withdrawal of the ice. The area of Lake Nipissing was very nearly coextensive with that of the present area of the Great Lake System.

Beach Formations.

During the summer and fall of 1899 and a portion of field season of 1900, the writer had an opportunity of obtaining detailed information concerning beach formations, which were in course of development during the history just sketched. In the summer of 1904 and 1905, Mr. Charles Holmes, formerly County Surveyor of Saginaw, ran 1339 miles of levels with the wye level and this has given a fine chance to determine the elevation of numerous old beach formations with accuracy. In the following account Mr. Holmes' elevations are indicated by a decimal point while my readings taken with a good aneroid barometer are only given for feet. In making aneroid adjustments a graph was determined giving the amount of variation of the instrument in feet per minute, from which the necessary correction could be made. In this connection it is necessary to state that Mr. A. C. Lane did the field work in R. 4 E., Tp's. 10-13 N., R. 5 E., Tp's. 12, 13 N., and a portion of T. 10 N., and all of T. 12 N. This includes much of the lower areas of Saginaw county and consequently a very considerable portion of the Lake Nipissing history which is only partially included in this account. The different beach formations will be designated by their elevation above sea level, or above tide (A. T.) and I have attempted to classify them according to that base.

702-715 foot beach.

This beach is well developed in the southern part of Saginaw county near the county line in T. 9 N., R's 1, 2 E., and the elevation as determined by Mr. Holmes in the S. W. ¼ of Sec. 34, T. 9 N., R. 1 E. was from 702.8 up to 714.8 and 714.9 A. T. In Brady, T. 9 N., R. 2 E., the following elevations were obtained with the aneroid and level.

Section	31,	east line,	715 A. T.
“	33,	north “	716 A. T.
“	35,	“ “	720 A. T.
“	31,	N. E. ¼	715.9 at top.

In Mt. Forest township, Bay county, T. 17 N., R. 3 E., there is a well developed beach at an elevation of from 720-734 with which this may correspond. Whether this is one of the Upper Grassmere or Lower Forest Beaches has not been determined. This may be one of the beaches noted by Mr. Lane in his Huron county report from 729 foot up.

680 foot beach.

In Lane's Huron county report we have the bottom of the Grassmere beaches given an elevation of 680 feet A. T. In Bay county there is a well developed beach near Mt. Forest station having a height of from 675-690 A. T., bottom and top. In Saginaw county and on the north line of Section 22, T. 9 N., R. 1 E., we find a former shore line 683 ft. A. T. at the top. In T. 11 N., R. 1 E. we have the following readings.

Section	9,	S. E. ¼,	684.8 at top.
“	10,	S. E. ¼,	684.3 “ “
“	9,	N. E. ¼,	686.8, 687.3.
“	9,	S. W. ¼,	687.3 top.
“	5,	T. 11 N., R. 2 E.,	683 at top.

651-665 foot beach.

With the next halt in the lowering of the lake level is found a well developed beach in the western and southern part of Saginaw county. In Chapin, T. 9 N., R. 1 E. the following determinations were made.

Section	4,	N. E. corner,	651.5–664.7, bottom and top.
“	5,	west line	664.8, top.
“	20,	“ “	665.3, “
“	8,	north “	661 “
“	17,	west “	661 “
“	9,	east “	662 “
“	14,	“ “	663 “
“	16,	“ “	664 “

In Marion, T. 10 N., R. 1 E. the following determinations were made.

Section	33,	east line,	662 top.
“	16,	“ “	663 “
“	9,	north “	663 “
“	9,	“ “	652.4–663.3, bottom and top.
“	33,	east “	664, top.
“	27,	“ “	665.
“	32,	county “	665.
“	28,	north “	666.
“	21,	“ “	669.
“	22,	“	660.3–670.8.

In Brady, T. 9 N., R. 2 E. the following elevations were obtained.

Section	14,	north line,	664 top.
“	11,	east “	666 “
“	19,	N. E. ¼	666.6 “

In Tittabawassee, T. 13 N., R. 3 E. and northwest of Saginaw this beach is again picked up where it is deployed on the Saginaw-Port Huron moraine,

Section	4,	north line,	664 top.
“	10,	“ “,	664 “
“	10,	“ “,	649–664 bottom and top.
“	10,	east “,	664 top.
“	5,	north “,	659–665 bottom and top.

In Richland, T 12 N., R 2 E. this abandoned shore line has been identified on the east side of section 29, elevation 665 and on the east side of section 33 where the elevation is 649.2-665.3, bottom and top.

This beach has been traced in Garfield township, Bay county, T 16 N., R 3 E. and has been reported on in the Bay county report, in the annual of the Michigan Geological Survey for 1905. This beach is apparently most nearly connected with the Elkton beach described by Lane in the Huron county report.

647-654 foot beach.

Closely connected with the preceding beach formation is found another abandoned shore line in the southwestern portion of Saginaw county in Marion, Brady, Chesaning and Maple Grove townships.

In Marion, T 10 N., R 1 E. this beach formation has been identified at the following localities:

Section	27, east	line,	647.4–654.3, bottom and top.
"	13, north	"	653, top.
"	35, "	"	654, top.
"	34, east	"	653.1 top.

In Brady, T. 9 N., R. 2 E. and southeast of Marion township this shore line is again apparently found on the north line of Section 17 at an elevation of 657 feet at the top. In Chesaning, T. 9 N., R. 3 E. the following locations are given.

Section	13, east	line,	653.5 top.
"	7, west	"	654 "
"	18, north	"	657.3 "

In Maple Grove, T 9 N., R 4 E. and to the eastward of Chesaning is found a beach on the east line of Section 18 at 659 A. T. at the top.

This abandoned shore line corresponds almost exactly with the elevation of the Elkton beach as given by Lane in the Huron county report. In Bay county to the northward this former shore line is found in Williams, Beaver and Garfield townships at an elevation of from 644-654 feet A. T.; bottom and top.

633-645 foot beach.

This beach is found generally deployed in Saginaw county as will be seen by referring to the following tables.

In Marion, T. 10 N., R. 1 E. Mr. Holmes obtained the elevation quite accurately on the east side of Section 35 where the height is from 633.8-645.3 A. T., bottom and top.

In Brant, T 10 N., R 2 E. the references to this beach are not so satisfactory, and in fact correspond in a way to the irregularities of beach formation in Bay county at this elevation.

Section	33, south	line,	627.9–638.3.
"	17, north	"	639 top.
"	18, "	"	640 "
"	33, "	"	640 "
"	19, "	"	631.7–643.3.
"	20, "	"	623.2–644.3.
"	18, S. W. ¼		643.3.
"	18, S. W. ¼		644.3.

In Richland, T 12 N., R 2 E. these elevations were obtained.

Section	33, S. E. ¼,	644.8, 647.3 top.
"	27, N. E. ¼,	648.3 top.
"	27, ¼ line,	636.5–648.3, 649.
"	3, east line,	646.
"	27, " "	649.

In Thomastown, T. 12 N., R. 3 E. this beach is found at substantially the same elevation.

Section	7, east	line,	642.
"	6, "	"	642.
"	17, north	"	646.3.
"	18, west	"	646.
"	8, S. W.	¼,	646.3.

In Tittabawassee, T 10 N., R 3 E. we get it again on the east line of Section 6 at 644 feet A. T., at the top. In Maple Grove, T. 9 N., R. 4 E, and on the east line of Section 8, Mr. Holmes made the elevation of this former shore line 643.3 feet A. T. In Taymouth township, T 10 N., R 5 E. the following references are given.

Section	24,	, 646 A. T.
"	35, N. E. ¼,	636.3.
"	36, west half,	636.3, 640 top.
"	35, S. E. ¼,	639, 640.3. top.

In Bridgeport, T. 11 N., R. 5 E. this beach is found on the east line of Section 14; 642.6 A. T. at the top. In Birch Run, T. 10 N., R. 6 E. and on the west line of Section 12 we have a beach at 641.6—649.3 feet A. T., bottom and top. In T. 11 N., R. 6 E. the following references are somewhat doubtfully given.

Section	18, S. E. ¼,	640.3.
"	18, S. W. ¼,	642.3.

In Blumfield, T. 12 N., R. 6 E. and on the Tuscola county line there is a gravel ridge at an elevation of 642.5 feet A. T. at the top.

618-635, 639 foot beach.

In Brant, T. 10 N., R. 2 E. this well marked shore line occurs as follows:

Section	27,	630 at top.
"	15, ¼ line,	631.
"	35, north line,	632.
"	35, south "	633.
"	13, N. W. corner,	634.
"	35, north line,	634.
"	15, ¼ line,	635.

In Fremont, T. 11 N., R. 2 E. equals 638 feet A. T. at the top on the north line of section 2.

In Richland, T 12 N., R 2 E. are a number of locations for this beach level.

Section	34, S. E. ¼,		635.9 top.
"	25, N. W. ¼,		637.3.
"	14, east	line,	627–635, bottom and top.
"	35, "	"	629–636.
"	13, north	"	636.9, 637.3, top.

In Chesaning, T. 9 N., R. 3 E., in the southern part of the county this beach is again found.

Section	5, north	line,	630 A. T., top.
"	12, "	"	631.
"	6, "	"	632.3.
"	10, east	"	633.

Thence northward from here in St. Charles, T 10 N., R 3 E. as follows:

Section 32, north line, 632 top.
" 31, south " , 628.4–639.3, bottom and top.

In Thomastown, T. 12 N., R. 3 E.

Section 15, north line, 618.1–635.3, bottom, top.
" 7, " " , 635, top.
" 18, west line, 638, top.
" 20, S. E. ¼ , 630.8 top.

In Tittabawassee, T 13 N., R 3 E.

Section 13, north line, 639 A. T. top.

In Taymouth, T 10 N., R 5 E.

Section 24, east line, 634, top.

Thence going northward again into Bridgeport, T. 11 N., R. 5 E. this beach is found at an elevation of from 619-631, bottom and top, in Section 23.

Southeast of Bridgeport, in Birch Run, this beach is found on the north line of Section 11, T 10 N., R 6 E. at an elevation of 638 feet A. T., at the top.

In the Bay county report this shore line was designated the Saganing beach. It is also described by Lane in his Huron county report.

Algonquin and transition Beaches.

In Saginaw as well as in Bay county we have apparently two old shore lines which represent halts and shore formations in the recession of this body of water. In the Bay county report this upper Algonquin beach has an elevation of from 610—623 feet A. T., bottom and top, while the lower built up beach ridge is from 593—610 feet A. T. The cut beach of the lower Algonquin in Bay county has an elevation of from 597—602, bottom and top. In Saginaw county this upper Algonquin beach, if such it proves to be, is more strongly and irregularly developed than in Bay county, while the lower beach is relatively undeveloped here in comparison with that shore line in Bay county. In the southern part of Bay county this lower Algonquin beach is less strongly developed than in Bay City, and thence north from there. The following elevations are here given for what may represent an Upper Algonquin beach in Saginaw county.

In Brant, T. 10 N., R. 2 E., as follows:

Section 23, north line, 616, top.
" 22, east " , 616, "
" 15, " " , 617, "
" 28, " " , 617, "
" 20, " " , 617, "
" 23, " " , 620, "

The levels from Mr. Holmes give a much better differentiation for this township.

Section 24, S. W. ¼, 621.3, top.
" 24, S. E. ¼, 622.9, "
" 23, S. E. ¼, 614.9–622.3, bottom and top.

Thence north into Fremont, T 11 N., R 2 E. there are the following elevations determined by Mr. Holmes.

Section 34, east line, 624. A. T., top.
" 11, " " 625.3.
" 10, " " 626.
" 1, " " 628.

Other determinations made with the Wye level in this same township show beach formations at 611.3, 614.3, 617.3, 617-619, A. T., at the top and it is quite probable that at least a portion are to be referred to a lower, more or less permanent elevation, of beach formation.

In Richland, T 12 N., R 2 E. there is a beach having an elevation of 624 feet A. T. at the top.

Thence south and east into St. Charles, T 10 N., R 3 E. we get the upper Algonquin well defined from the lower beach at the following elevations:

Section 19, S. W. ¼, 611.9–616.8, 620.3, bottom and top.
" 30, N. E. ¼, 617.8, top.
" 33, S. W. ¼, 618.3, "

Thence north again into Thomastown, T 12 N., R 3 E. we again get beach formations at irregular elevations.

Section 33, east part, 606–614, bottom and top.
" 24, 617, top.
" 27 state road, 603.0–617.3, top.
" 4, east line, 620, top.
" 3, north " 621, "

Section 30, east line 610–622, bottom and top.
" 30, east " 615–623, " " "

The following determinations were made by Mr. Holmes:

Section 4, N. E. ¼, 623.3, 625.8.
" 33, S. E. ¼, 600.9–613.3 and 625.3. Apparently two beach formations.
Section 6, N. E. ¼, 625.3, top.
" 10, S. E. ¼, 626.3, "

In Tittabawassee, T 13 N., R 3 E. and along the river road in Section 17, there is a beach having an elevation of 622 feet A. T. at the top.

Thence south and east again into the tier of townships next adjoining is found in Section 6 of Maple Grove, T 9 N., R 4 E., and northeast of the center, a beach at an elevation of 616 feet A. T. at the top.

In the S. W. ¼ of Section 6, T 11 N., R 4 E. is found a beach formation comparable to the one in Section 33, Thomastown having a height of 613.3 feet A. T. at the top. and probably referable to the lower Algonquin beach formation.

In Taymouth, T. 10 N., R. 5 E. we have:

Section 21, east line, 624, top.
" 24, " " 627.
" 18, west " 626.

There is also another set of beaches with an elevation at the top of from 611-615' A. T. Mr. Holmes gives beach determinations in this township as follows:

Section 4, north, ½, 614.3–615.8, top.
" 4, S. E. ¼, 616.8.
" 10, N. W. ¼, 617.3.
" 3, N. E. ¼, 620.3.
" 2, N. W. ¼, 620.3.
" 10, N. W. ¼, 620.3.
" 12, N. E. ¼, 625.3.

In Bridgeport, T. 11 N., R. 5 E. there is again suggested a slightly developed beach, lower than the highest Algonquin beach in Bay county, and higher in elevation than the normal altitude of the main lower beach of that area. This intermediate beach is also fairly well defined in the area under consideration.

Section 35, 617, top.
" 23, north line, 623, "
" 34, 624.
" 24, cemetery, 624.
" 24, north line, 625.

Coming down to the lower Algonquin beach which has in Bay county an elevation of from 593-610 feet A. T., bottom and top, the following observations are available in Brant, T. 10 N., R. 2 E.

Section 2, north line, 608, top.
" 13, ¼ " 608, "
" 25, N. E. ¼ 614.3, "

In Fremont, T 11 N., R 2 E. we again get a beach intermediate in height between the lower and upper beaches on the north side of Section 1 at an elevation of 617 A. T. at the top. In the N. E. of Section 25, Holmes determined the elevation of a beach having a height of 606.3 feet at the top.

In St. Charles, T 10 N., R 3 E. are the following elevations for the top of this beach.

Section 18, S. W. ¼, 607.3, top.
" 18, N. E. ¼, 607.3, "
" 18, state road, 607.3, "
" 22, ¼ line, 607 "
" 17, ¼ " 608 "

In Swan Creek, T. 11 N., R. 3 E. there are the following data:

Section 9, north line, 608, top.
" 19, " " 613.4 "

Thence north again into Jamestown, T. 11 N., R. 3 and 4 E.

Section 5, cemetery 606, top.
" 7, north line, 608, "

In Thomastown. T. 12 N., R. 3 E.

Section 11, 612, top.
" 35, N. E. Corner, 606, "
" 35, N. E. ¼, 601.5–610, bottom and top.
" 35, S. W. ¼, 605.8, top.

Thence east and south into the next range of townships are the following elevations in Taymouth township.

Section 21, east line, 611, top.
" 3, " " 612.
" 10, north " 603,–615, bottom and top.

In Bridgeport, T. 11 N., R. 4 E.

Section 31, east line, 606, top.
" 31, " " 607.9, "

Nipissing beach.

What may prove to be beach formations belonging to this stage of lake elevation are given below.

In St. Charles, T 10 N., R. 3 E.

Section 26, north line, 597 feet A. T., top.
" 15, S. W. ¼ 592.3 and 595.5, "

In Jamestown, T. 11 N., R. 3 and 4 E.

Section 1, east line, 600 feet A. T.
" 6, " " 601 " " "
" 2, west " 601 " " "

In T. 11 N., R. 4 E. Mr. Holmes gives the following elevations.

Section 24, N. E. ¼, 597.8, 599.8, top.
" 36, N. E. ¼, 600.3.

In Bay county the Nipissing beach is represented as having an elevation of from 587 feet A. T. at the bottom to 593, 598 feet at the top. In Huron county Lane makes the elevation 594 feet at the top.

Lansing, Michigan, March 30, 1908.

SOME POSSIBILITIES OF PEAT UTILIZATION.

CHARLES A. DAVIS.

For many years now, especially since the strike of the Anthracite coal miners in 1902-3, when actual fuel famine existed in most cities, and much of the country where anthracite is the principal domestic fuel, the attention of those who are familiar with conditions existing in Northern Europe, has been turned to peat as a possible undeveloped source of fuel supply.

The agitation of the subject has now gone so far that it may be said that there is a peat question, which, from the view-point of American economics may be stated as follows: "Can the extensive beds of peat which are found widely distributed over the country, especially in those parts remote from the chief centers of coal supply, be used profitably for fuel at present. If not, are they available for other purposes?"

For the proper discussion of this question it is necessary to have very clearly in mind, not only the existence of peat in sufficient quantity and of good quality for the uses intended, and the desirability of its being turned to account, but also the numerous other factors, practical, economic, and even psychological, which must be taken into consideration before a definite answer can be obtained.

While there is little opportunity in this place for considering the purely historical, some attention must be given to the history of the development of the utilization of peat in other parts of the world, if a fair start is to be made in this country, and the advantage is to be taken of the work, and the mistakes of others already well-advanced in ways of handling peat.

From time immemorial, cut peat, air-dried, has been used as fuel for domestic purposes in Northern Europe, and more recently in compacted forms, has been used, with considerable success as the source of energy for steam production on a large scale, the beginnings of experiments in this direction probably dating back to the early stages of the use of the steam engine for manufacturing purposes.

Even before the use of peat for the generation of steam, however, much experimental work had been carried on to make a better product than cut peat, and this resulted in the gradual development of machinery for drying peat, for grinding it while still wet, to make it more plastic and compact, and for molding it into blocks of regular size, thus making a more uniform and efficient product, which could be produced in larger quantities more certainly than cut peat.

These developments were largely made in Germany, a country always ready to investigate thoroughly any natural resources within her borders and develop them, to the greatest possible extent by careful and methodical research, and where, at the present time, studies of the possibilities of peat are still being pushed forward with energy.

With the greater demand for fuels which came with the increased use of the steam engine, and the industrial awakening in the Northern European countries, which has taken place in the past twenty-five years, renewed efforts were made to increase the efficiency of peat as a fuel, largely because other types of fuel were scarce and expensive.

The primary difficulty in using peat for fuel, lies in the great amount of water which it contains, and the slowness with which this disappears, even when the peat is placed in a dry place. This is due to the fact that the plant cells and tissues which make up the peat, hold the water, not only in the cavities of the cells themselves, but in their walls as well, and give it up very slowly, and only by evaporation, yielding but a small per cent of the total amount of water under pressure.

These facts, however, were only learned in Europe, after long-continued and expensive experimentation, costing in the aggregate millions of dollars. Through a period of years, attempts were made to get quickly rid of the water in peat by filtering and pressure, both by the application of vacuum and hydraulic pressure, reaching tons to the square inch, and also by the use of centrifugal machines, but, while the history of these attempts is of great interest, it cannot be entered into here at any length.

Nor can an account be given of the efforts made, and the machinery devised, to rapidly and thoroughly dry peat, as it was dug, by the direct application of heat generated by the use of fuel of various types, for, if this were done, there would be time for no other discussion. It is, therefore, perhaps sufficient to say that the best and most conservative students of the European peat fuel industry all agree that, up to the present time, no financially successful process of drying wet peat by the application of artificial heat has been discovered, and the only feasible way for accomplishing this is that which was first used, namely, exposure to the heat of the sun and air.

The reason for this has been summed up fully in the statement that three tons of dried peat, or its equivalent in heat units, are required to produce one ton by this method, so that, even where fuel is to be had for the cost of handling, as is the case of the refuse peat taken out of the bog, this cost is prohibitive. This is apparent when it is remembered that, even if the refuse is used in a partly-dried condition, a ton of fuel can only be obtained at the cost of digging and drying five or six tons of wet material, until it is free enough from moisture to burn.

Moreover, it is also well known that the higher the water content of any fuel, the less its efficiency when burned; thus, peat waste, having from 25 to 50 per cent of moisture, is reduced in fuel value, compared with the same material, perfectly dry, somewhat more than one per cent of the total number of heat units which could be developed from it, for every per cent of water which it contains.

Thus, giving dry peat a fuel value of 100, that with 25 per cent water has an efficiency of 72, that with 30 per cent moisture but 63, and that with 50 per cent water only 41 per cent of the fuel value of the perfectly dry material. It is, therefore, apparent that the amount of heat developed by one ton of the perfectly dry peat, can only be obtained by using a ton and a quarter, a ton and a third, and a ton and six-tenths of that which has 25, 30 and 50 per cent moisture, respectively, hence the amount to be handled both on the bog, and at the furnaces, is increased in direct proportion, and the cost of the artificially dried peat, instead of being three tons, has been increased to three and three-fourths, four, or even nearly five tons of material to be produced, according to the water content, and this excess must be charged to the cost of production, to which, also, must be added the cost of putting the dry peat on the market, and other fixed charges.

Still other efforts to improve the quality of peat, and to make it more transportable, are those directed to convert it into charcoal, or coke, and, while the problem of doing this successfully has been a complicated one, it seems to have been attacked with great earnestness, because of the desirability and value of the product. Most encouraging reports of its complete solution on a commercial basis reach us from Russia and Germany, where the Ziegler process of making peat coke seems to have gone beyond the experimental stage.

To sum up then: In Europe, extensive and very thorough study, and a large-number of experiments have been made, to produce an efficient and easily transported fuel from peat (1) By grinding and compacting, while wet, and drying in the air, (2) By drying artificially and briquetting in the dry state, (3) By taking the product of either of these processes and heating it in ovens r or in closed retorts, until the volatile matter is driven off, i.e., making charcoal or coke of it.

The work of development has gone farther than this, however, and mention should be made of the use of peat as a source of gas for illumination and power, its use in paper making, in the weaving of fabrics of various sorts, its extensive use as litter for stables and barns, an increasing use as the basis of stock food, for sanitary purposes in towns and cities, as a constituent of artificial fertilizers, and, by no means of least importance, the great improvement which has been made in the agriculture of the peaty soils by drainage and proper cultural methods, so that great areas, formerly considered untillable, have now become productive.

This brief sketch of the development of the utilization of peat as fuel and for other purposes has been made, not only to enforce what has already been said by others along the same line, but also with the special purpose of urging upon the attention of prospective investors, or inventors, the folly of commencing at the very beginning in this country, and trying to develop new processes and new machinery for handling peat, for any purpose, until a careful study has been made of the processes and machines which have been tried and are now in use in Europe. These may be faulty, and some of them admittedly are so, but they represent much careful and exhaustive study of the problems involved, and the expenditure of much time and more money, as well as the sum of the experience of practical men, actually working on the material on a commercial basis, and to ignore this storehouse of experience and knowledge, is to handicap the development of our peat resources beyond the limit of tolerance. That this has, in a measure, been done, however, is beyond question, and not a few of the failures of the attempts which have been made in this state to establish peat fuel plants may be directly attributed to this cause.

The amount of peat available for various purposes in this state is undoubtedly very great; as yet, in fact, we have little basis for even an approximate estimate of the quantity, but, assuming that even half of the swamp lands of the country are covered by peat suitable for fuel, and that this has an average depth of ten feet, the amount of fuel alone which is stored up in this way, amounts to billions of tons.

Moreover, these deposits of peat are widely distributed over the greater part of the eastern half of the continent, and, doubtless, over the moister parts of the western half as well, and there are notably widely-spread deposits in those regions so remote from supplies of coal, that the price of this commodity is sufficiently high to tempt capital to develop the peat, if it can only be shown that it is a practicable thing to do.

The history of the attempts at such developments, however, is not encouraging, when one goes over the field and enumerates the plants which have been built, run for a brief period, and then closed down indefinitely, without having marketed a ton of fuel with profit. It is not necessary to give a list of these experiments here, for, after a careful enquiry throughout the country east of the Mississippi, during the summer of 1907, the writer found but a single place where peat fuel was to be had as needed, namely, of the Commercial Artificial Fuel Company of Toledo, Ohio, whose plant was running and who were ready to contract to furnish a good quality of peat fuel in lots to suit the purchaser, at a reasonable price.

If the problem of developing an industry, or a number of industries from the peat deposits of the country is to be solved in a satisfactory way, it must be borne in mind that peat is not a single, simple substance, always uniform in all of its properties, but one which is not only very variable in characteristics, over wide areas, but which also may vary in a marked degree in the same deposit. In fact, variability must be expected in the mo t common type of bog, because of the way in which the peat has been formed, and throughout the region where peat deposits are most numerous, it is rather rare to find the material of the same structure from top to bottom of the beds, and in the very deep beds, this is still rarer.

The variations in the properties of peat are both physical and chemical, and are of such nature that-they cannot be considered here in detail; but, in general, it may be pointed out that peat varies from light brown to black in color, from the texture of a loosely felted fabric to a compact, solid substance, nearly like lignite or coal when dry, and varies as greatly in weight and plasticity, cohesiveness and in fuel value, as in other properties; it is probable that there are some definite relations between these variations in many cases, but not in all, by any means, and the reason for calling attention at all to them here is to point out the fact that no single industry can use all kinds equally well. For example, some types of peat, though low in ash, and having a high fuel value, are so light in weight, so poorly decomposed and so unplastic; that they make a very bulky, friable, and quick-burning fuel, which cannot be shipped any distance, or handled without much waste. Such peats, at best, are hard to work, and it is doubtful if they should ever be used for any except most local markets for fuel, and if a deposit of such peat is made the basis of large investment, for the purpose of developing a fuel industry, to supply distant markets, it is almost certain to fail to meet the anticipations of its projectors.

On the other hand, such peat might well meet the requirements of some other industry, in an almost ideal way, and be profitably worked from the beginning of the enterprise.

One of the most potent reasons which .has appeared to account for the failure of the many attempts to establish a peat fuel industry in this country has been the apparent ignoring this primary fact, namely, that the peat selected for exploitation was not adapted to the purpose for which it was decided to use it, nor to the type of machinery which was installed for its manufacture. Errors of this sort, however, are such as are likely to beset the path to success in any new and untried field of industry, and, while causing much discouragement and some serious financial losses, serve to stimulate the more persistent to renewed and more carefully directed efforts, and, at the same time, act as beacons to warn later comers to proceed more thoughtfully, if they would safely pass over such dangers.

Fundamental questions at this stage of the discussion should be: Are there opportunities in this country, such as occur abroad, to develop industries based on the utilization of peat as raw material? Are the conditions such that this material which occurs so widely spread and in such quantities, can be properly used in competition with equally good, or better, substances already in use and now holding the markets?

Considering it as a source of fuel supply, its most obvious use, and doubtless, that first to occur to the minds of most people as the one most likely to be successful, what are the opportunities and the possibilities and probabilities of success? At first thought and with but casual investigation of the matter, it would seem as if opportunities were practically as wide as the field over which fuel of any sort is used, and that peat has but to be made ready to use, and at once the demand for it will become general.

On more careful study of existing supplies of other fuels, and of the methods of distributing and handling these, however, one is led to the inevitable conclusion that for a long time to come, the larger markets will be chiefly supplied as they are now. This is a country of an abundance of good coal, which is to be had at moderate prices, over the greater part of the more thickly settled regions, and in the manufacturing districts. The trade in coal is so thoroughly organized, moreover, that a new type of material, competing with it, must necessarily make its way slowly, and especially will this be true of peat, which, at its best, must always be handled rather carefully and always be transported and stored under cover, in order to prevent loss or deterioration, and which is at the same time much more bulky than coal and a poorer fuel as well.

Aside from these factors, are some which may affect the would-be provider of peat fuel even more, namely, those arising from the consumers, such as a prejudice, which the average human being has against using a new thing, as a substitute for that which he knows and likes, or, the fact that furnaces, grates and other heating appliances are all devised for the use of coal, and would need some changes in order to get the best results from any other fuel. Not the least potent with the larger consumers, at the outset, would be the fear that once having adopted peat fuel, they might be unable to secure a constant supply. It is a well-known fact that some large industrial concerns, for example, carry at least a full year's supply of coal, as a reserve stock, and often have more than this available. From these and other causes, which could be mentioned, the prospects for founding a great peat fuel industry, which should soon be an active competitor with the coal trade are not good.

On the other hand, there are evidently innumerable opportunities in the direction of slow development of small, inexpensive, and carefully planned plants, equipped to supply limited local markets with fuel, for domestic uses or small manufacturing enterprises. There is opportunity for the utilization of peat for fuel in larger quantities, in regions remote from coal fields, like those lying west of the Great Lakes, and about the head of the Mississippi, as well as in Florida, and the adjacent regions, where coal is not only poor, and high in price, but wood also is of poor quality, and hard to get. In these regions, there are calls for fuel, which well-planned and carefully executed peat fuel developments would doubtless meet, and in them lie some of the most promising fields for the upbuilding of a large industry, based on the peat beds. Not only this, but the converse is true, that unless the peat beds of these regions are used for fuel, several promising industries have reached the limits of their expansion, although but recently established.

In still other directions, opportunity lies open for rightly directed effort, namely, in furnishing either charcoal, coke, gas, or all of these, or even electric energy, from peat beds of large extent, which lie sufficiently near industrial centers to make the demand for such development large enough to warrant an expenditure of the capital necessary to establish plants for these purposes.

The advantage of these forms of working up peat deposits, over those looking to transforming them into crude forms of fuel are obvious, but, since they are untried as yet, or only in the early stages of development abroad, it will be necessary to proceed carefully through experimental stages before larger expansion can be expected.

Of the possibilities of a peat coke, or charcoal industry, there is a large opportunity opening up extended vistas, which, seemingly, have no limits, since the demand for such a product as the coke must constantly increase, as the rapidly diminishing hard-wood forests are drawn on more and more for materials which must cause a decrease in the supply of wood charcoal, now used so extensively for metallurgical operations, and for which the peat coke is especially adapted.

It is remarkable that some of the more progressive iron mining companies, owning as they do, extensive tracts of swamp land, covered by good peat, in Northern

Michigan, Wisconsin and Minnesota, have not as yet erected experimental unit plants and begun the work which some of their progressive men already realize must soon be done. That they are making preliminary enquiries and watching the foreign peat coke developments is known, and at any time we may learn of the beginnings of an enterprise of this sort in our northern peat bogs.

In a small way, peat charcoal has been made in Connecticut, experimental work is being conducted in Massachusetts, and, although the success of these experiments has not been made public, they are the forerunners of an attempt to grasp a tempting opportunity to supply a large demand for a good substitute for wood charcoal, for domestic uses, now a scarce article. It is to be hoped that, before long, we may learn that whatever difficulties have been encountered in the e experiments are overcome, and the making of peat charcoal is a commercial success.

Much has been written of the possibilities of peat as a source of gas for illumination and power purposes, especially the latter, and again it is true that most of the work which actually has been done has been carried on abroad, with the notable exception of the recent experiments on peat as a source of gas in the producer gas engine, which were made by the Technologic Branch of the U. S. Geological Survey in its Fuel Testing Plant at St. Louis, and which were extended at the Jamestown Exposition. These trials gave highly interesting and significant results, and, if confirmed by later work on a more extensive scale, will open up much greater opportunities for the use of peat fuel than any other which has been considered, since, used in this way, the peat has nearly the value of coal, as the gas procured from it was equal to that given off by equal weights of coal of certain grades, and as efficient in producing power.

As the producer gas engine is being rapidly improved in various ways, and increased in size and power, and is also almost as rapidly displacing the steam engine as the motive power for many industries, this opportunity for peat utilization is not to be under-estimated, and its possibilities to the prospective peat fuel manufactures are very great, because, according to present lights at least, the peat, to be successfully used in the producer gas engine, must be machined and dried.

In considering the neglected opportunities which are offered by peat as a fuel, that presented to the small manufacturer by any of the numerous peat bogs which lie beside the railroads throughout a large part of our northern country, and are not wanting in the south, should be mentioned. Many of these would furnish what would be practically an inexhaustible supply of fuel, at a very low cost, to a manufacturing plant located on their borders, the chief cost being that of installing the machinery for preparing the peat, after which the only expenses would be those incidental to harvesting the fuel. At one place visited by the writer not long ago, a small factory was located, almost ideally on the edge of a large, fully cleared deposit of excellent peat, but using coal shipped several hundred miles by rail.

A word regarding the causes to which may be attributed, in part at least, the failure of the many of the peat fuel plants which have been started, aside from those already mentioned. The most potent cause for the failure of some, aside from those inherent in the process itself, has been the adoption of the briquetting process, with peat which was not adapted to such a process. In other cases, perhaps the majority, bad arrangement of the plant has contributed much to the lack of success. It has not seemed duly to impress the builders of such plants, that in handling wet peat, freshly dug from the bog, there was nine times as much water as peat thrown out, moved about, and carted to the factory, and often there is no definite arrangement for conveying the wet material which was dug, to its destination, except wheelbarrows or carts. By such arrangements the cost of production per ton of dried fuel is raised far above what it should be, considering the possible price after it is dry.

Another cause of failure has seemed to be the lack of a provision of sufficient drying space and proper division of the work. Similar to these difficulties were the attempts made with presses which were too large for the rest of the equipment, so that just as the press was running nicely, the supply of peat would give out and all hands would be obliged to go out after more, and, in the meantime, the press would stop, the steam go down, and, when a new run was begun, there would be tedious and costly waits before the machinery would run smoothly again.

Other causes, such as distance from railroad station, lack of knowledge and experience on the part of the owners, and too small capital to carry the plant through the experimental stages of development, have been operative, but those first mentioned are the ones most manifest to the casual observer. The remark of a shrewd business man, when asked by the writer not long ago if a peat fuel factory in his neighborhood was a success, is to the point: He said "He didn't know about the success, but he didn't think much of a business which took all the week to make enough product to take to market on Saturday in a two-horse wagon."

The opportunities for the development of other than the fuel industry from our peat bogs, seem to be even greater than those which lie in that direction. Already there is a peat paper factory in operation, with an assured output of a superior grade of paste-board, which is sold far ahead of the present time. The manufacture of peat litter as bedding for stables is also established in at least one place in Indiana, and the bogs where other factories might be located are numerous, in various parts of the country, and, judging from the reports which are given by those who have used this material, it is superior to all others now in use for this purpose. It should, in these days, find a ready sale to dairy farmers, and to horse owners in cities, to help them keep down the odors in their barns, as it is an efficient deodorizer, besides being cheaper and better bedding than straw.

Another growing industry based on peat, and one which has thus far proved a success from the start, is the manufacture of peat into "filler" for artificial fertilizers. While this use has been condemned by the agricultural chemists, as likely to be misleading, in that it makes the finished fertilizer seem higher in Nitrogen than it should, as it contains some Nitrogen which is not available for plants, it is mechanically really an ideal substance for the purpose, because it absorbs the water from the freshly made mixtures of the ingredients of the fertilizers and prevents caking and spoiling. How much of the water absorbed by the peat is sold as fertilizers, does not appear, but probably not so much, in proportion, as is sold in butter by the chief consumers of the fertilizer at from 25 to 35 cents per pound.

At any rate, the peat in the form of a dry powder, sold for this purpose, brings the highest price per ton of any peat product now on the market.

The purely academic and experimental uses to which peat has been put abroad, are, as yet, in too early a stage of development for more than passing mention here. In the opinion of the writer, they do not at present offer many opportunities in this country, which is so rich in better raw materials for the purposes to which peat has been put; but that one may easily misjudge in such matters is illustrated by the success of the peat paper mill already mentioned. That a good-sized factory should be established on a peat bed in Michigan, when thousands of tons of flax straw, apparently a vastly better material for paper-making, are annually burned to get rid of them in neighboring states, is certainly an anomaly.

It may be then, that artificial wood and paving blocks will yet be made here in quantities from peat, and this opportunity for peat utilization should not be overlooked as a possibility of much promise.

From what has been said, it is evident that there is a basis for the belief that is in us, that our peat deposits are valuable, that they will in the near future be the basis for extensive developments and will give rise to profitable industries; but, it is also evident that the development can only come from careful and thoughtful study of the possibilities of the basal substance, and, until this is thoroughly done, no one of us can be certain of success in any of the fields which have been opened up before us here.

PEAT DEPOSITS AS GEOLOGICAL RECORDS.

CHARLES A. DAVIS.

In the United States, peat has been but spasmodically and rather superficially studied, until recently, and practically not at all to determine its value as a record of conditions which may have existed during the time in which it was in the process of formation. The great area of the country, and its richness in unexplored fields for research, each attractive and important in varying degree, have kept busy those who might have turned to the study of peat from its geological aspects; and but few botanists have considered it within their realm of research, except as a paradoxical substratum, in which plants, having nearly all the forms of protection against the loss of moisture from their tissues possessed by desert types, were yet growing where the soil was always apparently wet.

A few writers, in a casual way, have published sufficiently elaborate papers to show how little they really had worked below the surface, on the subject, and others have frankly copied these and thus perpetuated incomplete work and erroneous ideas.

In Canada, somewhat careful and extended work has been done on the so-called "fossil" peat beds, marking an interglacial period. European writers have gone much farther than any others and have published some important studies of peat deposits in various parts of the British Isles, Scandinavia and Germany, which have thrown light on some of the possibilities of this interesting type of recent fossil beds.

The basis for intelligent .and profitable study of the geological history which is to be found in these deposits seems to lie in that fascinating field of botany which involves the relationships of plants to their environment, combined with the equally delightful study of physiography. In other words, before peat deposits, as such, can be profitably investigated, the way in which peat is now being formed must be thoroughly examined into, not alone from the viewpoint of the physiographer but as well from that of the plant ecologist. The deposits must be considered from the aspect of the origin and form of the surface on which they have been laid down, in order to know what lo expect as to types of vegetation which may be found.

Previous to such a study, however, it is essential to become familiar with the conditions under which peat may be formed, and the habits and ecological relations of the important groups of plants which are concerned in peat formation, as well as the ways in which these may be modified by various physiographic and climatic conditions.

The following underlying principles must be kept in mind in making interpretations:

(1) Peat is always found where the ground water level is sufficiently high to prevent ordinary decay; this implies complete saturation of the material for the greater part of the time. The more complete the seclusion of air, the less the vegetable matter shows true decay.

(2) Plants of but few types, and of simplest structure, are able to live wholly submerged in water, and the number becomes rapidly less as the water becomes deeper, until it is rare to find any species which is permanently attached by roots to the soil, growing from a depth greater than 15 feet below the water surface, the

maximum depth from which they start apparently depending upon the transparency of the water, although doubtless, other factors of growth must be taken into account. The floating Algae and the few seed plants which have no root attachments are not significant.

(3) Aquatic seed plants which have a part of their stems and leaves floating or emerged, grow in shallower water than the wholly submerged types, and become abundant in less than 10 feet of water, and; in the case of those with erect stems, rising much above the surface, 5 feet is about the maximum depth at which any are able to persist, while less than 2 feet limits the greater number of species. In water of less than this depth, a considerable number of species may give character to the vegetation.

(4) The turf, or mat-forming types, sedges and others, are limited lake-ward by a depth of water somewhat more than one foot, and will persist for a time to about the same height above water level; as these plants build the deposit above the water level, and prepare the way for the woody plants, their relations are important.

(5) As soon as the surface of a peat deposit is above water, a great variety of marsh plants, capable of enduring a good deal of water about their roots, take possession of it and change the character of the material making up the peat. Most characteristic, and usually appearing first, are the shrubs, especially the bog heaths and certain willows. Closely following these types come the coniferous trees, and more often, Sphagnum.

(6) It is apparent that this series is only to be found complete in depressions permanently filled with water. It is also evident that where moisture conditions are favorable, a deposit may begin with any member of the series—thus on a wet, poorly-drained land surface, in a moist climate, the peat may be built up wholly from a single association of plants.

(7) There are evidently two general kinds of peat deposits recognizable from the physiographic form of the surface, the filled depression and the covered flat surface, or the "filled" bog and the "built-up" bog.

Whatever may be the order in which these items are taken up, it is apparent that two lines of investigation must be pursued rather thoroughly, if the full significance of the peat is to be understood.

Perhaps the most readily obtained information to be derived from this class of deposits, is that regarding climatic conditions and changes during the period in which the peat has been forming. In the north of Europe, notably in Denmark, and Scotland, examinations have been made which show that in the case of certain peat deposits, there have been cycles of milder climatic conditions, followed, and preceded by more severe ones, as certain beds of peat contain the remains of southern plant species which are associated above and below with those of more northern types. In our own country but little is known of the records to be found in the beds of Post-glacial peat, so numerous in the glaciated regions of the continent. In a few cases, the writer has found definite records of prolonged drought followed by wet periods, which must have been of considerable duration, but it is only under rather unusual conditions that it would be clear that a rise of water indicated by a complete change in the character of the plant remains, was due to increased rainfall, and not to interference with the drainage. It is only in closed depressions of small extent that certain evidence may usually be found.

The evidence of climatic conditions, as expressed in inter-glacial peat deposits and soil beds, is, of course, well-known, and needs no elaboration here. Such beds are indications not only of the retreat of the ice for prolonged periods, but are definite records of their temperature and the humidity of the climate of the times. By much the same means that periods of drought and rainfall are indicated by the varying types of plant in the beds of a peat deposit, changes in drainage, due to various causes, are recorded. These changes may be due to the growth of the peat itself, and probably this is the more general cause, but the obstruction of outlets by drift material, by beavers, or in other ways, all produce the same effects.

It seems probable that, in many cases, such obstructions as result from the growth of the peat, may be correlated with drought periods, since in times of low water-level in the peat, such plants as the shrubs, trees and Sphagnum make rapid growth, cover new territory, and may invade the sides and even the bottom of the outlets, clogging them, or even obliterating them entirely, so that when normal rainfall appears again, the water does not find outlet at so low a level as formerly and a renewed stage of very wet conditions prevails for a longer or shorter time and is recorded by layers of plant remains showing the changes.

On the other hand, peat deposits of as great a thickness as 20 feet are known, which show, in a series of carefully taken samples, no marked variation in structure or in the type of plants building the peat; this may be interpreted as indicating conditions uniform with those of the present for the entire period.

Under certain conditions, the type of deposits under consideration may give records of movements of the crust of the earth, and, in some cases, form the most exact measure which can be obtained of the rate at which such movements are progressing.

A number of writers have called attention to deposits of peat at various stations along the Atlantic coast, which are now below the high tide level. During the summer of 1907, the writer had an opportunity to examine several such deposits at widely separated points along the coast; some of these were in salt marshes, while others, subjected regularly to tidal overflow, were covered by water that was nearly or quite fresh.

In the case of one salt marsh peat deposit, on the shore, near New Haven, Connecticut, the bottom of the deposit was a soil-bed with quantities of tree roots, stumps, etc., with a gravelly till below. The soil was nearly black, rich in humus, and was clearly similar to that usually found in tree-covered swamps of the present day, while the trees represented were swamp species of broad-leaved types. This layer was conspicuously darker than the peat above. Near the surface of the soil layer, shrub debris was abundant, and slightly above the root-crowns of the tree-stumps, these were replaced by an increasing quantity of the leaves and stems of sedges and other grass-like plants, above which for three or four feet such plants constituted the bulk of the deposit, forming a very characteristic, fibrous, brown peat, which was practically a turf, penetrated vertically by the roots of sedges and bulrushes. Above this the color and structure changed abruptly to gray, the peat became silty, and, instead of the sedge, the vegetable matter was practically all composed of the underground stems of the salt marsh grasses, now forming the covering of the marsh.

The story is plain, and scarcely needs interpretation, but it is certain that at one time the bottom of the deposit was above the high water level, and was a tree-covered swamp. Subsidence began, and the water, still fresh, was for some reason held back in the swamp to a higher level than formerly, so that the trees were drowned. The soil became so wet that humification ceased, the trees died, were replaced for a time by shrubs and then, because of still higher water level in the soil, by the sedges and bulrushes. For a long time the upbuilding seems to have been about equal to the rise in water, which here was due to subsidence of the bottom, but finally the level of the surface became so low that the tide reached it, and from that time on, the silt-laden salt water has left a clear record. The total subsidence recorded is not far from 6 feet, and the rate of subsidence was equal to the rate at which upbuilding occurred. The subsidence is apparently still continuing at about the same rate, as if it were going on more rapidly, there would be an invasion of plants more tolerant of salt water; if less rapidly, the surface would be built up and the present plant society would give place to one less "halophytic" or salt-loving. If subsidence had stopped, the same indication would be present.

At various points in New Hampshire and Maine, similar fresh water peat beds were found in salt marshes. One study, made at Cult's Island, Maine, was of especial interest, as it gave evidence of an elevation followed by subsidence. Below the present low water mark was found the characteristic deposit made by one of the salt marsh grasses which grows only above the half tide mark; this was capped by a turf identical in structure with the present surface deposit of the marsh, also below the present low water; superposed on this, was material which could have been formed only in a fresh water pond, above which in order came layers of sedges, shrub and moss, and then abruptly the peculiar mud, containing the underground stems of the salt thatch, appeared in the section, and at the top was the present turf. In another part of the same marsh, nearer the shore, the fresh-water material was considerably thicker, and the upper layers were abundantly filled by tree remains, both conifers and broad-leaved types being present. Evidently here the subsidence proceeded rather slowly, and the tide invaded the swamp gradually. This phase of the study of peat beds possesses so much interest, that one is tempted to prolong the discussion, but, after one more illustration, this time from North Carolina, it must be left.

Along the sounds of this state, especially those more remote from the sea and where the water is practically fresh, peat beds formed on a subsiding bottom are not uncommon. One such, near Elizabeth City, on Albemarle Sound, was more than 18 feet deep, and the structure of the peat was such that it is reasonably certain that the present conditions have continued throughout the time of its formation, that is, subsidence has been nearly uniform, with possibly slight halts, since it began. Halts in the subsidence would be indicated in such beds, by an accumulation of tree remains at definite depths. In a rather hasty examination of the deposit, no such tree bearing layers were found.

As to the rate of subsidence going on here, studies of the living plants growing on the deposit should show this: for example: one of the striking phenomena of these sounds to a stranger in the region, is the occurrence of living cypress trees growing in the water of the sounds, 100 yards, a quarter of a mile, or even longer distances from the shore; the question naturally arises, how did they get there and the obvious answer is Topsy's, “they jest growed." But even the least botanically inclined individual knows that no tree ever started from seed in several feet of water a quarter of a mile from shore, where there are strong currents and high waves constantly stirring up the sandy bottom. The same objection would prevent the assumption that these trees were sprouts from drifting trunks or branches. It seems apparent, then, that at the time these trees were seedlings, they were growing on soil, it may be on isolated bars or on the mainland, above the low water level, and that subsidence to the extent of some feet has gone on during their life-time, the number of years and the amount of subsidence could be found out by examination of the trees themselves.

If it is assumed that plants have grown n the past in similar relations to their environment, as at the present time, which may safely be done, modern peat deposits at once become the key to the conditions under which all deposits of vegetable origin were formed in past geological times. Beginning with the Present, the whole series of peats, lignites, coals and even graphites may give not only records of the plant types which have existed, but also of the conditions under which they grew, and thus supply many of the details of climate, precipitation, water level and of other factors controlling organic life, which are now unknown, because the records have been imperfectly interpreted. For example: Peat deposits, associated with bars and beaches of the glacial and post-glacial lakes, which existed in the basin of the Great Lakes, if buried by materials which are certainly contemporaneous with the lakes, may give conclusive evidence of the depth of water over the surface on which the peat was formed, and, in this way, of the water level of the lake for that period.

From principles which have been stated already, it is apparent that peat which has been formed on a wet land-surface, or in very shallow water, differs materially in constituent plants, and hence in structure, and other essentials, from that built up in deeper water of ponds and lagoons; that which has been formed by wave-worn drift material, brought together by wind and wave-formed currents, in eddies, behind bars and in similar places, where the current was slackened, is also easily distinguished from other types, and, where found, is obviously a record of importance to one seeking information relating to the shore deposits of these ancient lakes, and to water levels while they were being formed, provided that he can read them.

Only recently, a specimen of peat was referred to the writer for examination from a peat bed connected with the shore deposits of Lake Chicago, and which had been taken by various observers to indicate a low-water stage in the lake. Examination showed, however, that it was made up of heterogeneous drift material which probably accumulated in water of considerable depth, and which certainly did not form above water-level, or in a marsh, as a turf stratum.

Coal and lignite often show remarkably diverse vegetable structure even in beds of the same horizon, or in different layers of the same bed; but, instead of considering this an anomaly, it is probable that, in the light which the study of the peat should give, it is to be expected under some conditions which favored the development of the vegetation from the remains of which, both coal, and lignite have been developed.

In like manner, it is evident from the intimate association of peat formed from fresh and salt water vegetation, mentioned above, that it is not necessary to assume, as sometimes has been done, that coal which has marine fossils above and below, or even interbedded with it, was formed from marine algae or from plants growing on salt or brackish marshes. Marine fossils and the usually greater amount of ash constituents in the coal which occurs with them, when found at the top of coal strata, may simply mark the time when a subsiding coastal area of fresh marsh reached the level of the tides; when interbedded with the coal, it is more than possible that the deposit was formed upon an unstable coastal area which was oscillating up and down, or subject to occasional overflow caused by high tides, or severe storms, the thickness and character of the marine beds giving the evidence as to which factor should be given the greater weight. Marine beds below the coal may show nothing, except that there was an elevation of the surface before the coal began to be laid down.

To one who has examined the salt-marsh type of peat deposit, it is apparent that one of the most definite arguments which can be made against the hypothesis that coal could have been formed in marshes covered at regular intervals by the tides, is that the tidal waters are heavily silt-laden, and, wherever they appear, leave a heavy mineral deposit behind them. It is equally plain that an elevation or depression of a few inches, in an area near the tidal level will cause an entire change in the type of plants and in the resulting deposits.

It is scarcely necessary here, to call attention to the well-known and often-described power of preservation of the remains of animals and man, as well as those of plants, which peat possesses. The fact that this has been much more often noted in Europe than America is doubtless due to the more thorough development of industries based upon peat and its use as fuel, as well as the greater activity of geologists in working out the faunas of Pleistocene and Present times. A most excellent chance to increase the knowledge of the post-glacial faunas of Michigan is afforded by the present activity in draining marshes and ditching through peat deposits, and every large ditching operation should be watched, to save such vertebrate remains as may be uncovered. That such remains are of frequent occurrence, may be learned by talking with any intelligent ditcher, but it is only a rare occasion that any except the bones of the Mastodon are saved. Are we as geologists doing our duty in neglecting the opportunities thus offered.

A fascinating line of speculation may also be entered into as to the length of time which it may have taken a given thickness of peat, for example, measuring a period of coastal subsidence, to form. From this, it is but a step to conjecture as to the length of the time recorded in the accumulation of coal and lignite. Here, however, the knowledge obtained from the peat deposits is of the sort which puts the student in a very humble frame of mind, since he soon finds that practically each peat bed has its own rate of accumulation, depending upon so many factors that the problem is a most difficult one, if capable of solution at all.

It is apparently certain, however, other factors being the same, that peat develops more rapidly in a region of heavy rainfall, than in a more arid one, and, correlated with this, in a cool region than in a hot one, but the number of feet of peat which would develop in a given period, or the length of time in which one foot would be laid down, it is not possible to say with any definiteness, except for a given deposit after long-continued observation.

If these brief notes have served to call the attention of those present to a much neglected page of geological history, the aim of the writer is accomplished.

Ann Arbor, Michigan, April 3, 1908.

IS TOXICITY A FACTOR IN SOIL PROBLEMS?

A. DACHNOWSKI.

[Abstract.]

Various attempts have been made to account for the physiological dryness of bog habitats. The study here reported in part, and of which a more extended account will appear in the Botanical Gazette, may be summarized as follows:—

(1.) Osmotic pressure and acidity determinations of bog water from a bog island in a lake near Columbus, Ohio, reveal conditions similar to those found in Michigan bogs.

(2.) The bog island under consideration consists of peat forty feet in depth. Its surface vegetation has largely northern bog forms and presents two distinct zones. The bog island is virtually a water culture on a large scale. A series of cultivated plants when grown on the bog, show very marked dwarfing and various xerophilous characters.

(3.) A series of experiments in the form of bog water cultures variously treated gave the following transpiration data:—

PERCENTAGE INCREASE IN TRANSPIRATION.

Culture solution.	Wheat.	Corn.	Shaseolus mull.	Vicia faba.	Elm.	Buckeye.	Cowpea.	Oats.	Tradescantia.
I. Central zone:									
1. Bog soil extract*	0.	0.	0.	0.	0.	....	....	....	0.
2. Bog water untreated	19.	16.	113.	22.	68.	0.	0.	....	9.8
3. Bog water aerated	55.	27.	201.	....	....	1.3	20.	....	3.4
4. Bog water neutralized	209.	91.	....	100.	....	....	....	....	8.6
5. Bog water filtered	245.	52.	225.	215.	94	38.8	42.	....	24.7
6. Bog plant-water	54.	22.	184.	....	....	....	....		....
II. Maple-alder zone:									
1. Bog soil extract*	0.	0.	0.	....	....	....	....	0.	....
2. Bog water untreated	38.	65.	287.	....	....	....	....	90.	....
3. Bog water aerated	164.	71.	....	....	....	....	....	44.	....
4. Bog water neutral	298.	136.	335.	....	....	....	....	148.	....
5. Bog water filtered	256.	76.	....	....	....	....	....	....	....
6. Bog plant water	11.	40.	178.	....	....	....	....	113.	....

*4 grs. of bog soil extract and 400 cc. distilled water.

(4.) The corresponding differences in form and general appearance of some of the plants are illustrated in the accompanying plates.

(5.) The plants grown in the solutions treated with $CaCo_3$ and carbon black show not only accelerated growth and an increase in transpiration, but also an increase in dry weight. The increase in dry matter produced varied from 20% to 50% and more.

(6.) That the response to toxic bodies when present in small amounts may lead to acceleration of growth is also evident in connection with a biometric study on the annual wood-increment in Acer rubrum.

(7). The variety of material cited seems to offer sufficient proof that

(a) toxicity is a factor in certain soil problems;

(b) the inhibiting factors of bog conditions are in part clue to the presence of injurious, toxic, water-soluble substances—reactions of the plants themselves;

(c) these substances are formed in the absence of 62 and probably retard oxidation in the tissues as well as transpiration, thus causing stunting and even death;

(d) such toxicity can be corrected by various methods;

(e) an undrained peat substration must therefore necessarily cause a different succession of plants than a drained habitat.

Botanical Laboratory, Ohio State University.

EXPLANATION OF PLATES.

Half-liter jars of the Mason pattern were used, and prepared in the conventional way. The seeds were germinated in sawdust. Transplanting was done when the plants had attained a height of 5-6 cm. The culture media used were prepared as follows:

Solution 1 was made by taking quantities of the subsoil a foot below the surface vegetation and drying it in an oven at a temperature varying between 52° and 60°C. One gram of this was mixed with 100 cc. of distilled water.

Solution 2 was bog water untreated.

Solution 3 is bog water aerated daily by means of a rubber bulb.

Solution 4 was prepared by mixing into the bog water dry calcium carbonate and then filtering off the solution.

Solution 5 was treated by shaking the bog water with carbon (lampblack), and then filtering off the solution.

Solution 6 was obtained from a set of representative bog plants. These were grown in distilled water, in battery jars, and this water was then used as a culture medium.

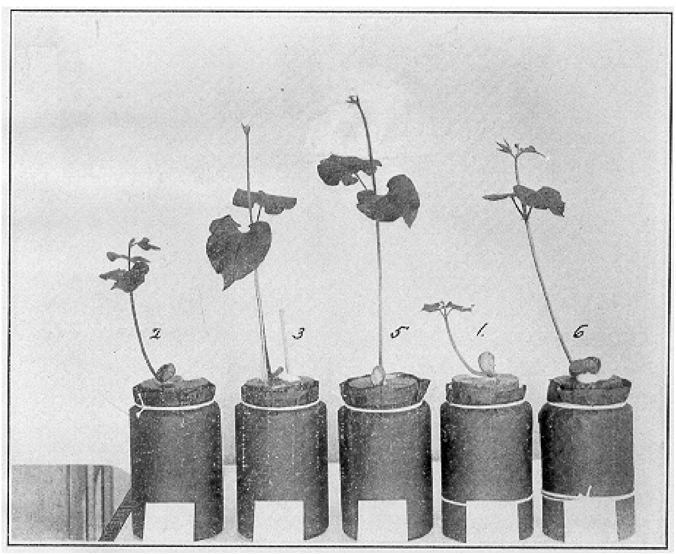

PLATE 1. PHASEOLUS.

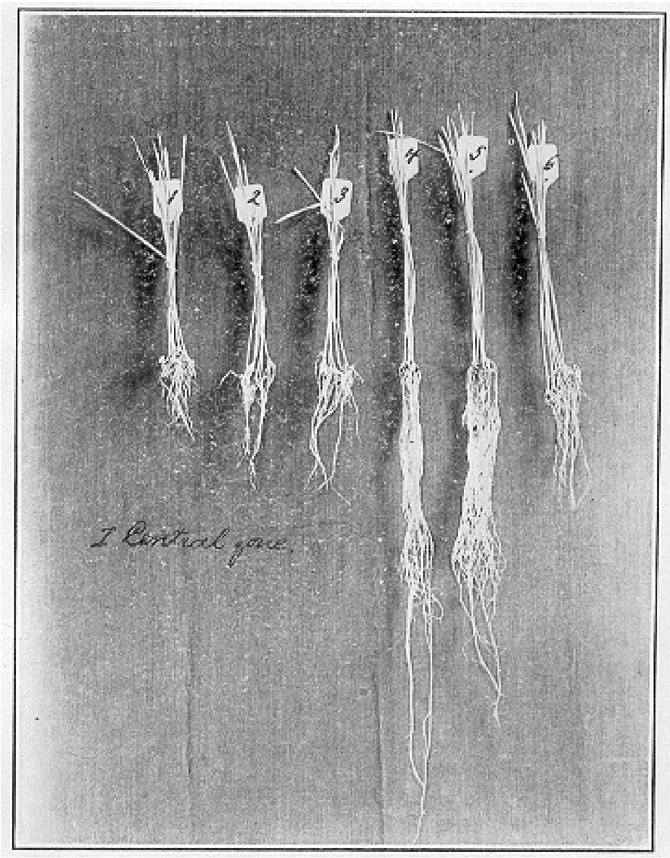

PLATE 2. WHEAT. CENTRAL ZONE.

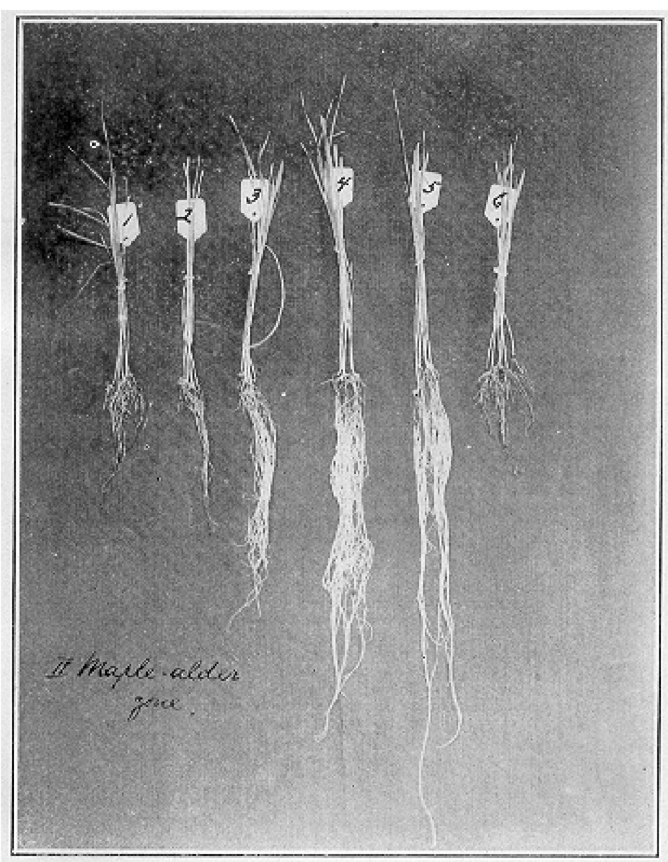

PLATE 3. WHEAT. MAPLE-ALDER ZONE.

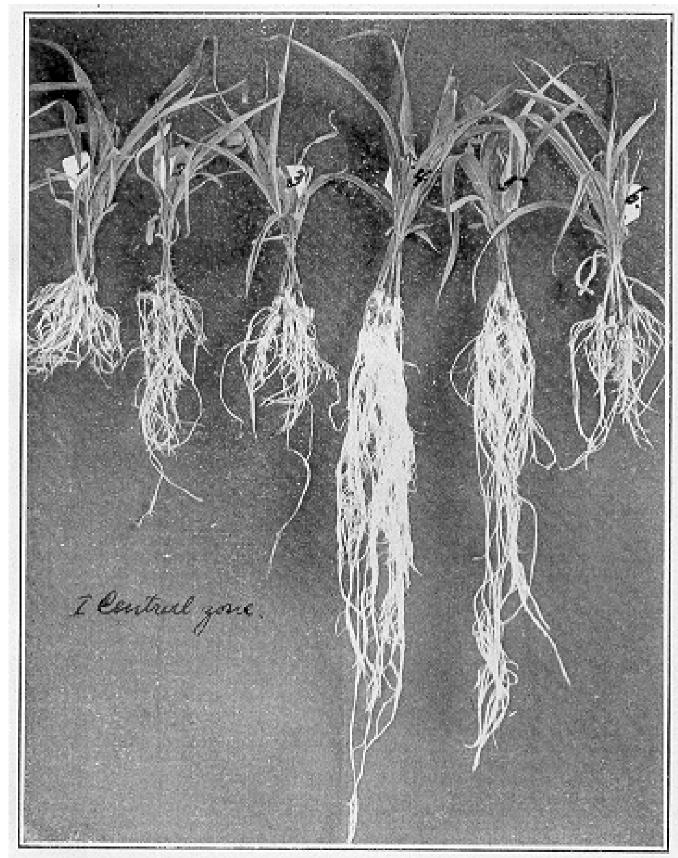

PLATE 4. CORN. CENTRAL ZONE.

PLATE 5. CORN. MAPLE-ALDER ZONE.